Registration of 'UI Darwin' Wheat

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ABSTRACT

'UI Darwin' (Reg. No. CV-1022, PI 639953) is a hard white winter wheat (*Triticum aestivum* L.) developed by the Idaho Agricultural Experiment Station and released in February 2006. UI Darwin (pedigree IDO445/'Manning') was tested under the experimental numbers A93151W-85 and IDO604. It is a tall semidwarf wheat released for crop-fallow rotations of the Intermountain West, where few hard white wheat cultivars are available. UI Darwin has improved resistance to stripe rust (*Puccinia striiformis* Westend.) relative to 'Bonneville' hard red winter wheat with resistance to dwarf bunt (*Tilletia controversa* Kühn in Rabenh) at similar levels to Bonneville. In 16 rainfed yield trials grown in Idaho from 2001 to 2005, UI Darwin had an average grain yield of 3200 kg ha^{-1}, similar to Bonneville (3050 kg ha^{-1}) and 'Weston' (3190 kg ha^{-1}) but less than 'Gary' (3560 kg ha^{-1}. UI Darwin has improved bread baking quality compared with current hard white winter wheat cultivars and has excellent color in akaline noodle products. UI Darwin had an average pup-loaf volume of 1075 mL, similar to hard red winter wheat cultivars Bonneville (1044 mL) and Weston (1064 mL) but greater than the hard white wheat cultivar Gary (963 mL).

'UI Darwin' (Reg. No. CV-1022, PI 639953) is a hard white winter wheat (*Triticum aestivum* L.) developed by the Idaho Agricultural Experiment Station and released in February 2006. UI Darwin, named for English naturalist Charles Darwin, was released for selected improvements in bread quality relative to hard white winter wheats of the Intermountain region of the western United States. UI Darwin is intended as a hard white replacement to the high-quality, hard red winter wheat 'Bonneville' (Souza et al., 1995). UI Darwin is best adapted to low-rainfall, crop-fallow production systems of the Intermountain West.

Methods

UI Darwin derives from a cross, designated A93151W, with the pedigree IDO445/'Manning'. IDO445 is a hard white winter wheat breeding line from the University of Idaho with the pedigree UT 216c-12-10/'Cheyenne'/5/PI 476212/4/'Burt'/3/'Rex'/'Rio'//'Nebred'/6/'Itana'*2/UT 175a-53//'Beadles Burt'/3/CI 13438/4/'Borah'/Rex//Rex/Rio/3/UT 175a-53/7/'Weston', CI*tr* 17727. Manning is a hard red winter wheat released by the Utah State University Experiment Station (Dewey, 1981). The A93151W cross was completed at Aberdeen, ID, in 1993, and F_1 seeds were planted in the field at Aberdeen during the winter of 1993–1994. Aberdeen has insufficient rainfall for normal winter wheat production and requires supplemental irrigation to recover seed in most years. Therefore, all Aberdeen trials described hereafter were irrigated weekly from April to July to replace approximately 75% of evaporative loss. This approximated moisture stress of the rainfed winter wheat production zones of southern Idaho. Irrigation methods and procedures for estimating reduction of irrigation are described in Guttieri et al. (2005). The progeny of the cross were advanced each year at Aberdeen by the bulk method for the F_2, F_3, and F_4 generations. Approximately 2000 plants were harvested each year. In 1997–1998, approximately 3000 plants of an F_5 bulk population were planted in rainfed plots at Rockland, ID, and 1000 heads were selected. Heads were selected for seed size, and the smallest seeded lines were discarded. Approximately 600 selected headrows were planted in the field at Aberdeen in 1998–1999. Approximately, 90 headrows were selected and harvested based on uniformity and resistance to common bunt [*Tilletia caries* (DC) Tul. & C. Tul.]. Inoculation, races, and evaluation of common bunt resistance were as described in Windes et al. (1995). Headrow grain was selected for strong gluten using a modification of the sodium duodecyl-sulfate–sedimentation method (Guttieri et al., 2004). White-seeded genotypes were selected for low polyphenyl oxidase activity using visual scoring of color reaction in a tyrosine solution (Bernier and Howes 1994). Of the headrows

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selected in 1999, 11 hard white-seeded selections were planted in unreplicated tests at Aberdeen, 1999–2000. Selections were planted in 2-m^2 plots with check cultivars and selected for lodging resistance and early maturity. Grain was evaluated for mixograph strength using standard AACC protocols as modified in Guttieri et al. (2005). Lines with strong gluten strength were also evaluated for alkaline noodle color using methods described in Souza et al. (2004b), and the lines with the brightest noodle color 24 h after sheeting were selected.

One line designated A93151W-85 was advanced to replicated testing from 2001 to 2005 based on yield, bread-baking quality, and dwarf bunt (*Tilletia controversa* Kühn in Rabenh) resistance. Replicated trials were grown at Aberdeen, but primary yield selection was based on performance in trials at southeastern Idaho rainfed sites at Arbon, Rockland, Roy, Preston, and Tetonia. Rainfed trials in all subsequent years were managed as described in Souza and Sunderman (1992). The experimental design of trials at all locations and years used a 10 × 10 partial lattice design (three replications). Seeding rates were standardized based on seed size to 1.6 million seed ha^{-1}. Bread-quality evaluations used standard AACC protocols (AACC 10-10B; American Association of Cereal Chemists, 1998) as described in Souza et al. (2004b). Dwarf bunt evaluations were as described in Windes et al. (1995). In 2003 A93151W-85 was designated IDO604 and entered in the Western Regional Nursery in 2003, 2004, and 2005. In 2003 approximately 200 heads of IDO604 were selected at Aberdeen and planted as head rows at Tetonia, ID. Rows of IDO604 that were uniform for height, heading date, and head type (approximately 150), were harvested and planted as plots at Tetonia, ID, in 2004 to form the Breeder seed for the cultivar UI Darwin. UI Darwin was evaluated in on-farm testing by the University of Idaho cooperative extension service in 2005 and 2006. Darwin is uniform for plant type without obvious phenotypic variants and has remained stable during six generations of evaluation, 2000 to 2005.

Characteristics

UI Darwin is most similar in appearance to the cultivar Bonneville. UI Darwin has an unpigmented coleoptile and a prostrate seedling growth habit. UI Darwin is a tall semidwarf plant type. It has an average plant stature in Idaho trials (20 trials) of 85 cm, similar to Bonneville (87 cm) and Gary hard white winter wheat (84 cm) (Souza et al., 2004a). UI Darwin has dark green foliage with slender, recurved, and nontwisted flag leaves. The inflorescence of UI Darwin is awned, mid-dense, and tapered, with glumes that are wide, midlong, with oblique shoulders and acuminate beaks. The last internode of the rachis is pubescent. The auricles and anthers of UI Darwin are unpigmented. UI Darwin has white chaff color at maturity. Seed of UI Darwin is hard white, ovate, with a shallow, wide crease and rounded cheeks. The brush on UI Darwin's seed is short in length and not collared. In five years of testing at Aberdeen, UI Darwin had large seed, averaging 41 mg per kernel, similar to Bonneville (39 mg per kernel) and larger than Gary (38 mg per kernel, SE 1 mg, $p < 0.05$).

UI Darwin is a mid-maturity winter wheat, with an average heading date in Idaho of 156 d after 1 January (12 field trials, 2001 to 2005), similar to Gary (157 d) yet 3 d earlier than Bonneville (Table 1). In most trials from 1999 to 2005, no lodging occurred; however, in six trials where lodging occurred, UI Darwin had an average score of 8% lodged plants, similar to Bonneville (19% lodged) but with less lodging than Weston (28% lodged, $p < 0.05$). In 16 rainfed yield trials grown in Idaho from 2001 to 2005, UI Darwin had an average grain yield of 3200 kg ha^{-1}, similar to Bonneville (3050 kg ha^{-1}) and Weston (3190 kg ha^{-1}), but less than Gary (3560 kg ha^{-1}, $p < 0.05$, Table 1). UI Darwin was released primarily for rainfed production in very low rain-fall zones of southeastern Idaho. Its grain yield was also comparable to Bonneville and Weston in the crop-fallow rotations where only one grain crop per two years is produced. The Roy, Arbon, and Tetonia locations used less-frequent fallow periods due to a combination of greater rainfall and higher elevation than the other yield trial sites. Yield trials at Preston and Rockland were produced on two-year, crop-fallow rotations due to limited

Table 1. Performance of hard winter wheats tested in southern Idaho, four year average.†

Cultivars	Class‡	Spring stand	Heading date	Plant height	Rain-fed locations grain yield	Grain wt. vol.	Grain protein	Grain yield	
								Rockland	Preston
		%	d from 1 Jan.	cm	kg ha^{-1}	kg m^{-3}	g kg^{-1}	kg ha^{-1}	kg ha^{-1}
UI Darwin	HWW	88	156	86	3200	809	138	2190	4050
Bonneville	HRW	90	159	90	3050	803	141	2120	3830
Boundary	HRW	88	157	73	3470	783	137	2540	4250
Deloris	HRW	87	156	88	3640	799	132	2280	4200
DW	HRW	87	156	75	3240	799	124	2640	4610
Eltan	SWW	89	160	78	3630	775	123	2700	4770
Gary	HWW	90	157	84	3560	790	123	2420	4500
Juniper	HRW	89	156	102	3290	802	134	2340	4210
Utah 100	HRW	87	156	87	3480	783	131	2340	4610
Weston	HRW	85	154	94	3190	809	137	2060	4140
Standard error		1.3	0.4	0.5	90	3	3	160	210
No. of environments		16	12	20	16	12	9	4	4

†Rainfed trials at Rockland, ID, 2002 to 2005; Preston, ID, 2001, 2003 to 2005; Roy, ID, 2002 to 2005; Tetonia, ID, 2001 to 2004; Arbon, ID, 2004 to 2005. Heading date and plant height data includes irrigated trials at Aberdeen 2001 to 2005. When data was collected at an environment, information was recorded for all cultivars at that environment. Not all traits were recorded in all environments.

‡HWW, hard white winter; HRW, hard red winter; SWW, soft white winter.

Table 2. Summary of 4 yr of milling and baking evaluations from hard winter wheat yield trials grown in Idaho, 2001 to 2004, 14 environments.†

Cultivar	Class	Flour protein	Flour yield	Mixograph			Bake time	Bake absorption	Loaf vol.	Texture	
				Peak	Height	Tolerance				Exterior	Interior
		g kg^{-1}	g kg^{-1}	min	cm	degree	min	g kg^{-1}	mL	0–5	0–5
UI Darwin	HWW‡	115	672	2.9	6.4	71.3	2.6	59.6	1075	1.5	1.6
Golden Spike	HWW	108	680	2.6	6.2	72.7	2.4	58.6	1025	1.5	1.7
Gary	HWW	105	661	3.6	5.8	76.4	3.1	58.3	963	1.2	1.5
Bonneville	HRW	118	693	2.8	6.1	72.3	2.3	60.8	1044	1.4	1.6
Boundary	HRW	105	681	3.0	5.8	77.9	2.7	57.7	889	1.1	1.5
DW	HRW	112	672	3.4	6.4	73.3	2.9	59.3	1064	1.5	1.6
Juniper	HRW	117	674	2.4	6.2	73.7	2.1	60.2	1051	1.3	1.5
Utah 100	HRW	112	668	2.5	6.4	71.3	2.1	59.5	1052	1.6	1.6
Weston	HRW	118	676	1.6	6.9	62.2	1.4	60.7	1064	1.4	1.6
Standard error		4	6	0.2	0.2	2.1	0.2	0.7	36	0.1	0.1

†Rainfed trials at Arbon, ID, 2001, 2003, and 2004; Preston, ID, 2001, 2002, and 2004; Rockland, ID, 2001, 2002, 2003, and 2004; Roy, ID, 2002; and Tetonia, ID, 2001, 2002, and 2003.

‡HWW, hard white winter; HRW, hard red winter.

rainfall at these locations. In these trials, UI Darwin was equal in grain yield to Weston and Bonneville, the other tall cultivars grown on crop-fallow rotations (Table 1). In Western Regional Nursery trials from 2003 to 2005 (12 site-years, Garland-Campbell and Little, 2003, 2004, 2005), UI Darwin had an average grain yield of 4150 kg ha^{-1}, compared with 3300 kg ha^{-1} for the tall-stature winter wheat 'Finley' (Donaldson et al., 2000), and 4880 kg ha^{-1} for the semidwarf 'Boundary' (Souza et al., 1999). UI Darwin had an average grain volume-weight in southern Idaho rainfed trials (12 trials, 2001–2005) of 809 kg m^{-3}, similar to Weston (809 kg m^{-3}), yet greater than Bonneville (803 kg m^{-3}, $p < 0.05$) and Gary (790 kg m^{-3}, $p < 0.01$, Table 1). In nine rainfed yield trials grown in Idaho from 2001 to 2005, UI Darwin had an average grain protein concentration of 138 g kg^{-1}, similar to Bonneville (141 g kg^{-1}) and Weston (137 g kg^{-1}) but greater than Gary (123 g kg^{-1}, $p < 0.01$, Table 1).

UI Darwin appeared to have adult plant resistance to the dominant races of stripe rust (*Puccinia striiformis* Westend.) in Washington and Idaho during 2004 and 2005. In Washington during this period, UI Darwin typically did not develop rust pustules when the disease was present. In trials when rust pustules formed during the juvenile stage, the adult reaction on the same plants restricted the disease to 2 to 20% of the leaf area, and the most common reactions were type 2 and type 5 (type 2, flecking; type 5, necrosis and restricted pustule formation; Chen et al., 2002). 'Stephens' (Kronstad et al., 1978), a check cultivar for adult-plant stripe rust resistance, had a similar range in reactions in 2004 and 2005. In late season (1 July) observations at Pullman, WA, 2004, both Stephens and UI Darwin had type 8 reactions (pustule formation without observable host-plant resistance reaction), with rust covering 60% of Stephens' flag leaf and 2% of UI Darwin's flag leaf. In the same trials, susceptible spreader rows had 90% or greater of their leaf area covered with stripe rust pustules. The race spectrum of the stripe rust pathogen during this time period was complex (dominant races in 2003: Pst 98 and Pst 100; 2004: similar to 2003 with Pst 114 and Pst 115; data courtesy of X. Chen, USDA-ARS, Pullman, WA, 2005). In 2005 replicated field trials at Aberdeen, Rockland, and Preston, ID, UI Darwin had type 0 (resistant) to type 4 (moderately resistant) reactions to stripe rust infection, similar to Bonneville yet more resistant than the type 5 to 6 (moderately susceptible) reactions for Weston (races Pst 98, Pst 100, Pst 114, and Pst 115; X Chen, personal communication, 2005). In the same trials, the susceptible hard red winter wheat cultivar Deloris (Hole et al., 2004) had susceptible type 8 reactions at all locations.

In three years of Western Regional Nursery evaluations at the Green Canyon site (near Logan, UT), UI Darwin had dwarf bunt resistance similar to Bonneville, where both had an average rating of less than 1% infected tillers compared with the susceptible check cultivar Cheyenne (PI 192268) that had an average of 90% of tillers bunted. UI Darwin has good stand establishment and winter survival characteristics. UI Darwin has moderate resistance to snow mold (*Typhula* spp.) based on evaluations in 16 southern Idaho trials from 2001 to 2005, where snow mold significantly reduced spring stands; UI Darwin had a spring survival of 88%, similar to the resistant cultivars Bonneville (90%) and Gary (90%) and greater than the susceptible cultivar Weston (85%, $p < 0.05$, Table 1).

The University of Idaho Wheat Quality Laboratory evaluated the end-use quality of UI Darwin by milling and baking seed samples of each entry from 14 rainfed yield trials grown in southern Idaho from 2001 to 2004. Wheat was milled using a Quadrumat Senior experimental flour mill (AACC 26-21A), evaluated with a mixograph (AACC 54-21) to measure dough strength, and a pup-loaf bread bake (AACC 10-10B) to assess loaf volume (AACC, 1998). UI Darwin had a milling yield of 672 g kg^{-1}, similar to Weston (676 g kg^{-1}), greater than Gary (661 g kg^{-1}, $p < 0.05$), and less than Bonneville (693 g kg^{-1}, $p < 0.05$) (Table 2). UI Darwin had an average flour protein of 114 g kg^{-1}, similar to Bonneville and Weston (118 g kg^{-1} for both) but greater than Gary (105 g kg^{-1}). Mixograph dough mixing time for UI Darwin was 2.9 min, similar to Bonneville (2.8 min), longer than Weston (1.6 min, $p < 0.01$), but less than Gary (3.6 min, $p < 0.01$). The mixing tolerance of UI Darwin was 71.3°, as measured by the angle of the mixograph curve arriving and departing from peak, similar to Bonneville (74.3°) and Gary (76.4°) but greater than Weston (62.2°, $p < 0.01$ (Table 2). UI Darwin had an average pup-loaf volume of 1075 mL (SE of all values, 36 mL), similar to Bonneville (1044 mL) and Weston (1064

mL), but greater than Gary (963 mL, $p < 0.05$) (Table 2). Alkaline noodles of UI Darwin were sheeted from composite samples of the Western Regional Nursery in 2003 and 2004. Noodle sheet color was measured in Commission Internationale de l'Eclairage (CIE) tristimulus color space (*L*, a*, b**) using a Minolta CM-2002 spectrophotometer (Minolta Camera, Chuo-Ku, Osaka, Japan) with a 50-mm measurement aperture. UI Darwin's alkaline noodles were bright 24 h after sheeting (83.4 *L**), compared with Finley (80.2 *L**) and Boundary (79.1 *L**) (Garland-Campbell and Little, 2003, 2004, 2005). Using the standard UI alkaline noodle protocol (Guttieri et al., 2005), across two years and five trials, UI Darwin had an initial noodle brightness of 80.5 *L** (SE of all values, 0.3), less than measured for Gary (81.6 *L**, $p < 0.05$). However, both cultivars had a similar change in *L** after sheeting, 7.8 *L** decline over 24 h for UI Darwin and 7.5 *L** decline for Gary (SE for all values, 0.3 *L**). The initial color of alkaline noodles from UI Darwin had a *b** value of 21.5, less yellow than noodles of Gary (23.2 *b**, $p < 0.05$).

Availability

Seed of UI Darwin will be maintained by the University of Idaho, Foundation Seed Program, 3793 North 3600 East, Kimberly ID 83341. Plant Variety Protection will not be sought for UI Darwin, and seed will be freely distributed to all interested parties.

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